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Circularly Polarized Broadband RFID Microstrip Tag Antenna

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Abstract- In recent years, the application of radio frequency identification (RFID) operating in the ultra-high frequency (UHF) band (860-960MHz) are expanding exponentially, due to the advantages such as long reading distance, high data transfer rate, and small tag size. So the design of a CP tag antenna with broadband characteristic is presently one of the most challenging topics. This project presents a square patch passive RFID tag antenna designed for UHF band. To achieve compact size broadband and circular polarization (CP) radiation, the square patch is embedded with a cross slot, while an L-shaped open-end microstrip line coupled to the patch. By selecting an appropriate length for the microstrip line and its coupling distance with the radiating element, easy control on the input impedance of the designed tag antenna which leads to excellent impedance matching is achieved. The measured 10-dB return-loss bandwidth of the tag antenna is 27MHz (from 901–928 MHz).

Key words: Circularly polarization, microstrip antenna, Radio Frequency Identification (RFID), tag antenna.

I.Introduction

The increasing need for automatic identification and object tracking in various applications has led to the development of radio frequency identification (RFID) systems. Radio Frequency identification is a rapidly growing technology which uses RF signals for automatic identification of objects. Now RFID finds many applications in various areas such as animal tracking, vehicle security ,asset identification, retail item management, Supply chain Management , Electronic Toll Collection etc.,

Auto-ID technology is implemented in several different ways, which includes barcodes, lasers, voice recognition and biometrics. These techniques have limitations such as the need for line-of-sight (LOS) with the interrogator (lasers and barcodes), low data storage capacities (barcodes) and human intervention (voice recognition and Biometrics).Radio Frequency Identification (RFID) was developed to overcome these limitations.

RFID systems are generally distinguished through four common bands; low-frequency (LF) (125-134 kHz), high-frequency (HF) (13.56MHz), ultra-high frequency (UHF) (860-960MHz), and microwave (MW) (2.45GHz or 5.8GHz). Each operating frequency has its own characteristics. LF bands have low data-transfer rates but are good for operating environments with metals and liquids, while HF bands have more reasonable data-transfer rates compared with LF bands and penetrates water but not metal. UHF and microwave tags can offer comparatively very fast reading, but their performance will suffer more than the other bands described above in the presence of liquid or metal.

At present, commercially available RFID tags operating in the UHF band are commonly designed as dipole[1] or Microstrip type [2]–[4] with linear polarization (LP), thus, the polarization mismatch between the reader and tag will results in only half of the transmitted power received by the LP tag. Theoretically, the maximum reading range of a CP tag can be improved by approximately 41% when the reader is also a CP type (exhibiting the same rotation), which is due to a 3 dB increase in power received by the CP tag. The CP Microstrip antennas can be categorized into two general types as according to the feeding point quantity; namely, single and dual-feed antennas. Single-feed CP Microstrip antennas fabricated using various radiating patches (of different geometries) can be achieved by adding perturbation segments, such as truncated corners [5]–[7], cross-shaped slot [8]–[10],slits [11], [12], and tuning stub [13].

Microstrip antenna designs with CP radiation have been extensively studied for many years, and they are usually applied to 50- wireless communication system [3]–[7]. Generally, it is easy to find the 50- feeding position within the surface area of the radiating patch for these conventional CP designs. However the RFID tag chip is usually designed with low resistance and high capacitive reactance. To realize maximum power transmission, the input impedance (with inductive reactance) of the tag antenna must be conjugate matched to the tag chip.

This paper discus about a square patch passive RFID tag antenna designed for UHF band. To achieve compact size and circular polarization (CP) radiation, the square patch is embedded with a cross slot, while an L-shaped open-end microstrip line linked to a tag-chip and terminated by a shorting pin is capacitively coupled to the patch. By selecting an appropriate length for the microstrip line and its coupling distance with the radiating element, easy control on the input impedance of the proposed tag antenna which leads to excellent impedance matching is achieved. This antenna is simulated using Ansoft HFSS software.

II.Antenna structure

Microstrip RFID tag antenna consists of a radiating patch on one side of a dielectric substrate which has a ground

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plane on the other side shown in fig.1.Cross slots are embedded in to the square patch. These two narrow slots are located centrally along x- and y- axis. L shaped open end microstrip line is coupled to the rectangular patch. The coupling distance between patch and microstrip line d is 3mm.This antenna is fabricated on an inexpensive FR4 substrate. In this antenna microstrip line feed techique is used..

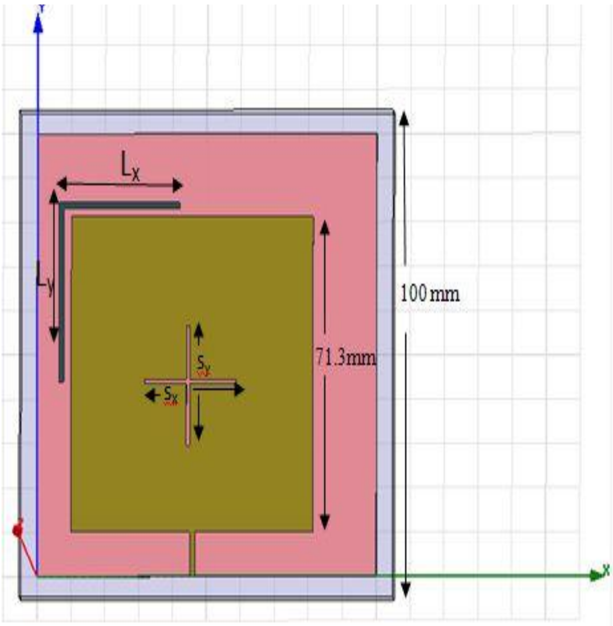

Fig.1.Geometry of the proposed circularly-polarized RFID tag antenna (unit: mm).

The proposed circularly-polarized RFID tag antenna is fabricated on an inexpensive FR4 substrate, with thickness 1.6 mm and relative permittivity 4.4 A square patch is printed on the ground plane, cross slots loaded on the square patch coupled to an L-shaped open end micro strip line. Both horizontal and vertical sections of the micro strip line are located along the x and y directions, respectively, with dissimilar lengths. As for the cross slot embedded into the square patch, it is formed by two narrow slots located centrally along the x- and y- axes with different lengths.

III. Impedance matching technique and design procedure

The impedance matching technique between the RFID tag chip and the tag antenna is discussed in this section. An Alien IC Higgs RFID tag chip with impedance 13.5-j111Ω is used at 915MHz.To achieve an input impedance of 13.5+j111Ω for the tag antenna, vital parameters L_x and L_y of the open-end microstrip line, and the coupling distance d must be carefully selected. In this design, the imaginary impedance of the proposed tag antenna is mainly contributed by the inductive reactance of the open-end microstrip line.

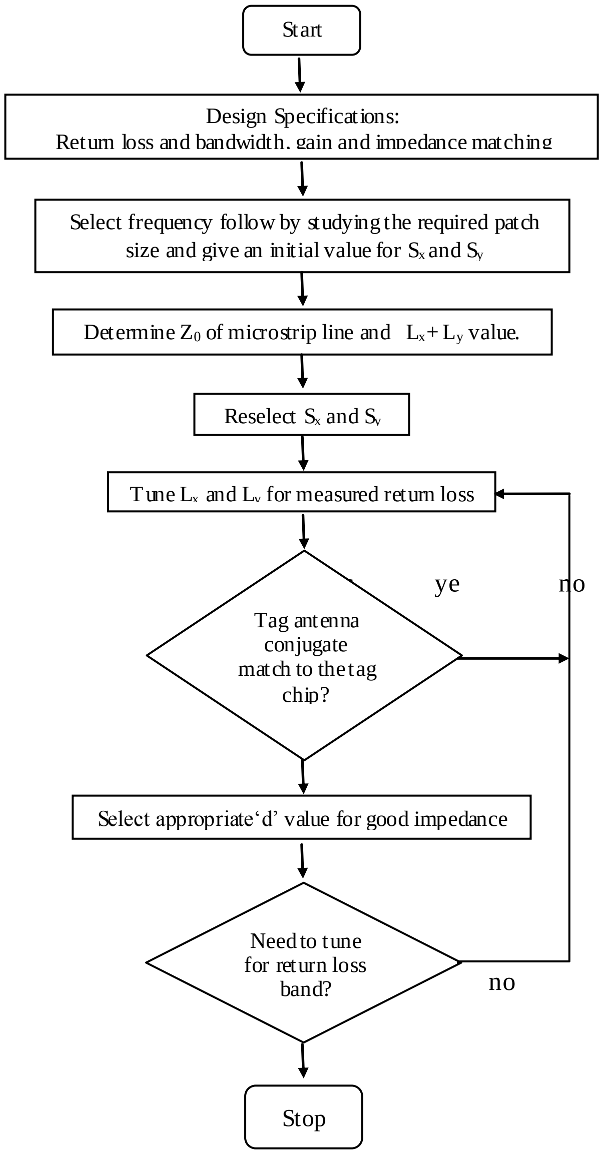

Fig.2. Flowchart of antenna design procedure.

To induce an inductive reactance of j111Ω, the length of the open-end Microstrip line can be estimated as follow:

$$Lx + Ly = \frac{\lambda_0}{2\Pi}\cot^{-1}\left(\frac{-111}{Zo}\right) \qquad (1)$$

Zo is the characteristic impedance

$$Z_0 = \frac{60}{\sqrt{\varepsilon_{eff}}}\ln\left(8\frac{H}{W} + 0.25\frac{W}{H}\right) \qquad (2)$$

The real part of the input impedance at 13.5Ω,it can be obtained by tuning the coupling distance d between the open end Microstrip line and square patch. The following design guideline are shown in Fig. 2 (flowchart diagram) is suggested for choosing the optimum value for L_x ,L_y ,d ,t ,S_x and S_y, so that desirable CP and band width Performance can be achieved. For choosing the optimum value for t, d, Lx,$L_{y,}$ $_{Sx}$ and S_y, so that desirable CP performance can be achieved.

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IV.Results and discussion

The design and development of the proposed tag antenna was achieved by using the commercially available electromagnetic simulation software HFSS, in which the initial behaviors and performances of the proposed tag antenna can be thoroughly studied. The measured return losses of the proposed tag antenna when tuning the length, L, is shown in fig.

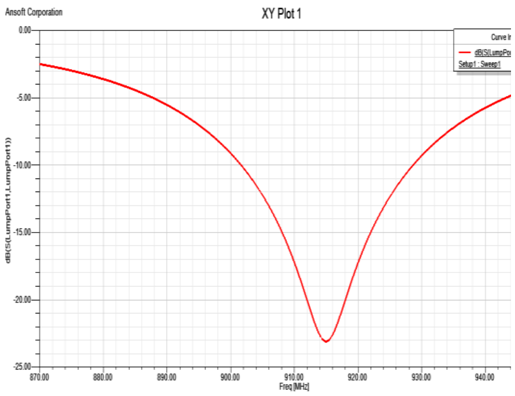

Fig.3 Simulated return loss against frequency for the antenna.

Bandwidth of the return loss

The measured 10-dB return-loss bandwidth of the tag antenna is MHz (from 901–928 MHz). The measured 6-dB return-loss bandwidth of the tag antenna is 46 MHz (from 892–938MHz). The measured 3-dB return-loss bandwidth of the tag antenna is 82 MHz (from 876958MHz)

An increase in d will result in decreasing the input resistance. When around 2 to 3 mm, good impedance matching over a wide frequency range can be obtained, and their corresponding bandwidths can cover the desired bandwidth of 901–928 MHz. The gain of the proposed tag antenna is -6.4dB as shown in fig.4 and total radiation pattern of the proposed tag antenna is shown in fig.5.

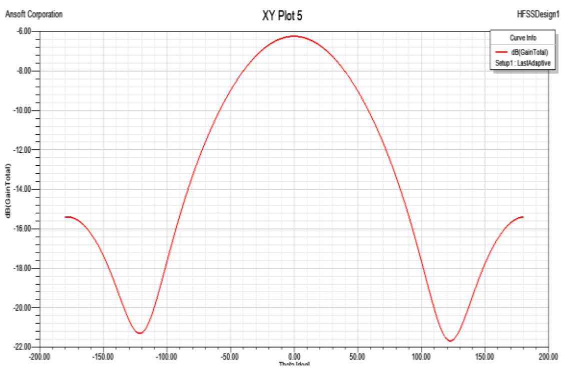

Fig.4 Simulated antenna gain against the theta

Changing the coupling distance d significantly influences the impedance characteristics of the antenna, but slightly affects the CP performance. The tuning of both parameters S_x and S_y will affect the CP performances of the proposed tag antenna, however, since both parameters are orthogonal to each other and their optimized lengths are almost equal.

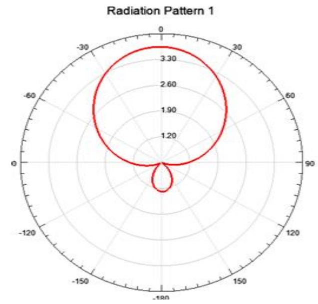

Fig.5 Simulated total radiation pattern at 915 MHz for the proposed tag antenna

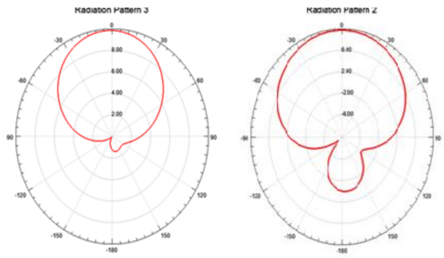

Fig.6 Simulated radiation patterns for E_θ and E_φ fields.

The values of E_θ and E_φ in the boresight direction are nearly equal, which imply that the proposed tag antenna has CP radiation shown in fig.6.

Read range of RFID Tag Antenna

Read range of RFID Microstrip tag antenna is calculated by considering the friis formula

$$r_{max} = \frac{\lambda_o}{4\Pi}\sqrt{\frac{p_t \rho G_r G_t (1-|\Gamma|^2)}{p_{th}}} \qquad (3)$$

where λ_o is the wavelength, P_t is the output power of the reader, P_{th} is the minimum threshold power necessary to provide enough power to the tag chip, G_r = is the gain of reader antenna, G_t = is the gain of tag antenna, $\boldsymbol{\Gamma}$ is the reflection coefficient of tag antenna, and ρ is the polarization factor. Both the reader antenna and the tag antenna are left-handed circularly polarized, thus $\rho = 1$. Read range of the proposed RFID tag antenna is 2.84m.

V.CONCLUSION

An RFID tag antenna with Circularly Polarization radiation and broad band was simulated for UHF band (from 901–928 MHz). Two feeding techniques (microstrip line feed and coupling feed) are implemented for Circularly Polarization and proper impedance matching between tag chip and tag antenna. Furthermore, when mounted on a large metallic surface, a significantly increased reading range is also exhibited. Hence, this proposed tag antenna is a good for any RFID applications in the UHF band.

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